SOME DIATOM HOOPS.

The Question of their Mode of Growth (Aulacodiscus Kittoni.)

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The hoops of diatoms have such relation to the growth of the frustules and to the process of their increase by division, that a careful study of this portion of the organism will sometimes throw unexpected light upon its general life-history. The mode of growth of the hoop itself presents an interesting question, which, so far as I know, has not been settled. Does the hoop grow by accretions upon the edge, or is the whole formed at once out of the living contents of the frustule? The former of these views has weighty authority in its support, but the latter seems to me more in accord with observed facts and with the recognized principles of vegetable growth. It may fairly be admitted, however, that there are difficulties in the way of either hypothesis, and that the subject is a fit one for careful observation.

The most noticeable difference between the hoops of different species of diatoms is found in the fact that some of them are hyaline, whilst others are elaborately figured and ornamented with markings more or less resembling those of the valves. It seems clear, upon examination, that the figured hoops are generally persistent, forming a permanent part of the diatom structure. Of these, *Isthmia nervosa* and *Biddulphia pulchella* are familiar examples, the same broad hoop remaining attached to the valve through oft-repeated formations of new valves within it as the self-division goes on. This is true not only in those genera which form irregular filaments of frustules adhering by stipital points, but also in the filamentous *Melosireæ*, where the more perfect adhesion simulates a continuous tube or stem.

The hyaline hoop seems usually to belong to the free swimming forms and those closely parasitic species in which a single frustule alone remains sessile upon and closely adherent to a larger alga or other support. In this, as in so many other cases, nature would appear to abhor a waste, even of ornament, and a bare simplicity marks the parts which are cast off after a momentary use.

Some years since I made a series of notes upon the characteristics of the growth of *Aulacodiscus Kittoni*, Arn., which offers an interesting example of the growth, ripening and separation of the hyaline hoop in a species of which the valves are strongly and elegantly marked. The substance of these notes, with some conclusions from them, I shall lay before you.

The normal form of this diatom is a convex disc with four short but large processes, from which run to the center conspicuous double lines of large areolæ, giving to the valve the well-known appearance of being marked with a cross, of which the rays end in the hollow side of the crescent-shaped processes. In the two valves of the frustule these processes are not opposite each other, but are placed alternately; and so long as two or more frustules remain in a temporary filament, they are interlocked by each process fitting into the hollow between those of the neighboring valve.

The hoops are hyaline, and divided by well-defined sutures into five, six, or more parallel bands or rings. These sutures are unusually well marked, the refraction of the light through them giving the whole hoop a corrugated appearance, as if it were considerably thickened over the suture line. This, however, is shown to be a mere optical illusion, by the fact that the hoops slide over each other when the new frustules separate after the self-division of the parent.

The most noticeable characteristic of these hoops is that the sutures are not continuous lines going quite around the shell, but at one place curve sharply upward toward the valve, so that a tooth from the next outer division of the compound hoop cuts through its neighbor. These teeth alternate upon different sides of the shell, so that if it be placed with a series of the teeth toward the observer, they appear to divide only the alternate rings of the hoop; but upon focussing the microscope upon the opposite side of the shell, similar

teeth will be found in the intermediate rings of the hoop (*fig. 1*). If, then, the hoop be divided upon the lines of these sutures, it will be found to be made up of a connected series of imperfect rings or bands with a projecting tooth upon the edge, and with the curved ends of the band separated by a space into which would fit a similar tooth upon the adjacent band of the hoop (*fig. 2*).

Fig. 1

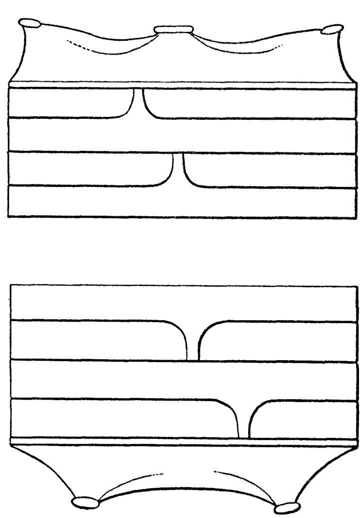
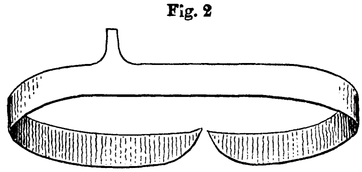


Fig. 2



As the projection of these teeth is toward the valve with which the hoop is connected after the telescopic sliding of the hoops begins, it follows that the teeth of the interior hoop point in the opposite direction from those of the exterior, and before the sliding process begins, the effect, to the eye, is as if each band or ring were doubly sutured into teeth, one projecting toward each valve; for the lines of the division of these bands coincide as to the rest of their extent, and it is next to impossible to tell by direct examination whether a given tooth is in the exterior or interior hoop till the sliding process begins. Then it becomes plain, as I have stated, that the direction of the teeth have a fixed relation to the valve to which each hoop is attached, and uniformly point toward it. The position of the teeth in the several bands or rings of the same hoop are not entirely symmetrical, though they are approximately so.

When the fission of the parent diatom is complete and the two new frustules slide apart, the hoops have ripened so that the sutures between the bands open at the slightest touch. The division of each band by the tooth of the neighboring one, allows it to spring open, and the frustule (or pair of frustules ready for separation) is thus freed from the hoops, which fall to pieces of themselves.

If we examine such a hoop before it has ripened, we find that though the lines of the sutures are perfectly visible, the adherence of the rings is so firm that the whole hoop will break in other places as quick, or nearly as quick, as upon the suture lines. But if we happen upon an example which has been fully ripened, a slight moving of the covering glass or the touch of a bristle will make it instantly separate at the sutures into its half dozen parts lying loosely upon each other in the field.

I think no one can examine this mechanism without being convinced that it is designed to facilitate the escape of the new diatoms from the shell of the old one, and that it points toward this easy escape and separation, just as the broad flanges of the *Isthmia* and *Biddulphia* point to a firm and lasting continuance of the connection between hoop and valve in those genera.

The facts which I have described, seem to me also to bear directly upon the question of the mode of growth of the diatom hoop. If we suppose the hoop to grow (when the sliding process goes on) by the deposition of silex upon the free margin, this would be in a continuous and regular accretion. How then could we account for the sutures, and the symmetrical division of the hoop into the toothed rings which we find? We must bear in mind that the hypothesis must apply to the outer lamina as well as to the inner, and that too, after the separate inner hoop has been formed. If this hoop were itself a multicellular structure, we might think of its growth as of the leaf of a tree; but since the whole diatom is unicellular, it seems to me that we can only conceive of the formation of its walls from the living mass within, and that once the outer hoop, stiffened with silex, is separated from the cell contents by another silicious wall over which it slides, the idea of growth at the edge of this outer wall becomes untenable.

If, on the other hand, we think of the membrane as formed upon the vital contents of the cell itself, as its epiderm, the differentiation of its parts by sutures or by other markings, is in accord with our experience of the formation of vegetable cell walls in general. The growth of an inner one, or the splitting of the wall by intersusception, would also be in the line of our botanical knowledge of other families. The singular stiffening of the walls by the deposit, or

secretion, of the silex which is the characteristic of the Diatomaceæ, would introduce the mechanical feature of its growth by the sliding of the hoops upon each other, but would leave all the other characteristics of vegetable cell growth in harmony with the rest of our botanical knowledge, or at least not in conflict with it. The silex punctuates and makes permanently visible the areolation of the cell wall, but this marking of the wall is in no wise inconsistent with the law of structure in other single vegetable cells.

In the case of *Aulacodiscus Kittoni*, the fact that the teeth formed in the sutures of the exterior and interior hoops point in different directions, seems to me to indicate strongly the formation of successive walls of the cell, each from the live contents of the cell itself, and each having a special polar relation to the valve to which it especially belongs.

I do not overlook the fact that the whole diatom is enveloped in a gelatinous covering, but I see no evidence that this has any vital function to perform from without upon these silicified cell walls. Even if this gelatinous covering be not a mere excretion, it would properly rank only as a soft exterior coat, and the vital processes which determine the structure of the silicified inner wall, would, in every single cell, be most philosophically considered as working from within outward.

The considerations which I thus submit in regard to the diatom I have taken as an example, may be with equal force drawn from the characteristics of other genera of the family. The peculiarities of this shell, however, have not before been fully described, and for this reason, as well as for their bearing on the general question of diatom growth, they have seemed worth the presentation to the Society.